

## REMARKS

The claims remaining in this patent application following amendment are claims 1-3 and 5-20. Claim 4 has been cancelled. Original claims 22-52, which are the non-elected claims, have been previously withdrawn from consideration. No new claims are presented. Claim 1 has been amended.

The Examiner's objection to the form of claim 4 is noted. Accordingly, claim 4 has been cancelled, without prejudice, whereby any further objections are now rendered moot.

Claims 1-16 and 18-20 are rejected under 35 U.S.C. 103 as being unpatentable over the patent to Haidn (6,151,887) in view of the patent to Smith (5,523,133). This rejection is respectively traversed. As indicated above, claim 4 has been cancelled and, therefore, the rejection thereof is rendered moot. For the following reasons, each of claims 1-3, 5-16, and 18-20 appearing in this patent application is believed to be patentable.

In the Amendment filed August 8, 2003, independent claim 1 was amended to recite a ceramic matrix composite tubular shell structure having an outer wall, an inner wall, and a plurality of cooling channels formed therebetween, and further comprising a fibrous preform of refractory fibers, wherein said refractory fibers extend continuously through said inner and outer walls and around said plurality of cooling channels to maximize the structural integrity of said shell structure. Independent claim 1 has been once again amended merely for purposes of clarity so as to point out that the refractory fibers extend continuously between the inner and outer walls of the applicant's shell structure and around said plurality of cooling channels. This feature has

already been emphasized by the applicant and recognized by the Examiner. Therefore, no new matter is presented and the aforementioned clarification raises no new issues.

To function as a reliable rocket propulsion thrust chamber, the applicant's ceramic matrix tubular shell structure must be capable of performing two pressure vessel functions. The first function is performed by the combination of the inner and outer shell walls working together as an efficient coupled pressure vessel structure to provide containment of hot combustion gases to assure the exhaustion thereof through an outlet nozzle. In this case, the pressure within the inner wall is usually quite high. A second, and more critical function of the tubular shell structure is also performed by the inner and outer walls of a cooled combustor so as to enable containment of the coolant flowing through the cooling channels formed between the inner and outer shell walls. In this case, the coolant pressure is usually much higher than the combustion pressure (see, for example, column 4, lines 40-49 of the patent to Wagner (4,781,019) which has been listed in the Office Action).

As a consequence of this pressure differential, the inner wall and outer wall of the compound shell tend to split apart, and the inner wall may fail inwardly by a buckling instability. To prevent such mechanical failure, the inner wall must be adequately attached to the outer wall to prevent buckling instability and other failure modes (see, for example, column 4, lines 23-63 of the aforementioned patent to Wagner). In the present invention, the applicant provides for the efficient and robust attachment of the inner and outer walls by means of refractory fibers extending continuously between said inner and outer walls and around the plurality of cooling channels formed between the inner and outer walls to maximize structural integrity, thereby

producing a strong single-piece unitized monocoque tubular shell structure. While the applicant's reinforcing fibers travel across the attachment surface and are common to both the inner and outer walls, there are no identical or equivalent fibers described or considered by Haidn which extend across the attachment surface in the matter recited in independent claim 1.

As the Examiner has pointed out (at page 7) in the Office Action, Haidn does make use of inner and outer shell walls which are first fabricated as separate shell structures and then subsequently connected together by a secondary bonding operation to form an integrated assembly. That is to say, the inner and outer shell walls of Haidn are integrally connected together by means of a silicon braze bonded interface. However, nowhere in Haidn is there the slightest reference or suggestion for the inner and outer walls to be integrally fabricated or connected by means of refractory fibers that extend continuously between said inner and outer shell walls and around the cooling channels formed therebetween to maximize the structural integrity of the shell structure as recited by the applicant in independent claim 1.

As the Examiner has also pointed out (at page 3) in the Office Action, Haidn teaches a combustion chamber formed as an integral structure from an inner shell comprising a fibrous ceramic material and from an outer shell comprising a fiber reinforced silicon carbide. From this, the Examiner has jumped to the unsupported conclusion that "the refractory fibers extend continuously throughout the inner and outer walls and around the plurality of cooling channels." However, according to Haiden's teachings the integral structure is really a bonded assembly comprising two separate, prefabricated shell elements, which are subsequently bonded together as a unit using a secondary bonding process.

Despite the fact that the inner and outer walls of Haidn are integrally connected together (as noted by the Examiner), such integral connection is achieved in Haidn by secondary bonding and not by means of integral fabrication wherein the reinforcement fibers extend continuously between the inner and outer walls as claimed by the applicant. Any conclusion to the contrary is based entirely on speculation and not on any specific teaching by Haidn. In fact, what Haidn actually teaches is that solidified silicon (i.e., a silicon braze or bond) is the means for achieving the integral shell structure to which reference has been made by the Examiner. In this same regard, Haidn also indicates that CVI or liquid polymer infiltration and decomposition can also be used as the bonding agent to attach the separate shell walls together.

By virtue of the applicant's improvement which relies on a truly integral (i.e., monocoque) fiber reinforced composite structure, wherein refractory fibers extend continuously between the outer and inner walls of the shell structure, a much stronger and more reliable vessel is possible than the silicon braze attachment taught by Haidn. Thus, a rocket propulsion thrust chamber including the applicant's ceramic matrix composite tubular shell structure would be far better able to withstand the significant thermal and mechanical shock loading which occurs during start-up as well as the normal differential between the cooling pressure and the combustion pressure. This same shock loading is less likely to cause shell failure in a thrust chamber that relies on the relatively high strength refractory fiber connection claimed by the applicant rather than the more brittle silicon braze taught by Haidn.

In summary, it may be that Haidn teaches a combustion chamber having inner and outer walls that are formed as an integral structure. However, such integral structure is achieved only

by first fabricating separate inner and outer shell walls and then subsequently attaching them together using a cooled molten silicon (i.e., silicon braze) interface and not by refractory fibers that extend continuously between the inner and outer walls in the manner recited by the applicant in the independent claim 1. In other words, despite the fact that the inner wall of Haidn may comprise a fibrous ceramic material and the outer wall may comprise a fiber reinforced silicon carbide, there is absolutely no teaching or suggestion, whatsoever, in Haidn to attach the inner and outer walls together by means of refractory fibers that extend continuously between said inner and outer walls and around the plurality of cooling channels formed therebetween.

To this end, attached hereto is a Declaration of Robert Holzl pursuant to 37 CFR 1.132. This declaration is included to verify the applicant's interpretation of Haidn and to point out that Haidn is devoid of any teaching of refractory fibers extending continuously between inner and outer walls of a shell to attach said walls together to form a unitized monocoque structure as recited by the applicant in independent claim 1.

Accordingly, and regardless of the teachings of Smith, independent claim 1 is believed to be patentable over any reasonable combination of Haidn in view of Smith. Inasmuch as independent claim 1 is believed to be patentable, each of claims 2, 3, and 5-20 which depends therefrom is likewise believed to be patentable.

Claim 17 is rejected under 35 U.S.C. 103 as being unpatentable over the aforementioned patent to Haidn in view of the aforementioned patent to Smith in further view of the patent to McAninch et al (5,221,045). Claim 7 is dependent from independent claim 1. Inasmuch as

independent claim 1 is believed to be patentable, claim 17 which depends therefrom is likewise believed to be patentable.

In view of the foregoing, each of claims 1-3 and 5-20 remaining in this patent application is believed to recite a patentable invention. Accordingly, reconsideration of the Examiner's rejection is requested and a Notice of Allowance is earnestly solicited.

A one month extension of time is also attached by which to extend the deadline for responding to the Office Action until March 10, 2004.

Respectfully submitted,

  
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Dated



### **CERTIFICATE OF MAILING**

I, Christine Dayeh Ohannessian, do hereby certify that the foregoing documents are being deposited with the United States Postal Service as First Class Mail, postage prepaid, in an envelope addressed to Mail Stop: Fee Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria VA 22313-1450 on this date of March 5, 2004.

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